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Gartside Dam,
Crane, Montana,
Richland County,
MT-349

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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GARTSIDE DAM
CRANE, MONTANA
RICHLAND COUNTY
MT-349

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

STATE OF MONTANA
DEPARTMENT OF FISH, WILDLIFE, AND PARKS
(OWNER AND OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

NOVEMBER 1980

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UNITED STATES
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PHASE 1 INSPECTION REPORT
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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation and the Department of Fish, Wildlife, and Parks, CH2M HILL inspected Gartside Dam on October 30, 1979, under the authority of Public Law 92367. The dam is located on Crane Creek, a tributary of the Yellowstone River. Gartside Dam is located in Richland County, about 0.75 mile northwest of Crane and 10 miles southwest of Sidney, Montana.

This report was prepared from information obtained during the onsite inspection, review of preliminary computations, and an analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies that are engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Gartside Dam is owned and operated by the State of Montana Department of Fish, Wildlife, and Parks. The reservoir is used for recreation and minor amounts of water are withdrawn for irrigation use.

The 30-foot-high earth dam impounds approximately 1,020 acre-feet of water at assumed top of dam, elevation 2011.8 feet NGVD. On the basis of criteria in the U. S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. Based on a brief field inspection and engineering judgment, several homes, the Lower Yellowstone Project Main Canal, a highway, and a railroad could be affected by a sudden breach of the dam.

However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and on engineering judgment. The project is classified as having high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that the spillway design flood (SDF) for an intermediate-sized project with a high downstream hazard potential be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated PMF was developed for the 32-square-mile drainage basin. Refinement of this estimate may either increase or decrease the final flood characteristics. The estimated PMF resulting from the 72-hour general storm has a volume of

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44,800 acre-feet and a peak flow of 64,900 c.f.s. The principal and emergency spillways have a combined maximum discharge capacity of 5,650 c.f.s with the reservoir at assumed top of dam, elevation 2011.8 feet NGVD. Routing of the estimated PMF was started with the reservoir at assumed emergency spillway crest, elevation 2005.0 feet NGVD.

The routing indicates that:

a. During the full PMF the dam would be overtopped when approximately 11 percent of the flood volume had entered the reservoir.

b. Routings were made of hypothetical floods less than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 10 percent of the PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

The dam is made of materials that would quickly erode and rapidly fail if overtopped by floodwaters. Based on reconnaissance level investigations, the project in incapable of handling a flood having one-half the PMF ordinates without overtopping and causing the dam to fail which, in our judgment, would seriously jeopardize life and property downstream. Also, the 200-foot-long slide in the downstream embankment slope is of concern from a stability standpoint. Under inspection criteria, Gartside Dam is considered unsafe until the recommended actions are complete.

The 24-inch CMP discharge conduit, which carries flows from the outlet works and the principal spillway, could not be inspected during the site visit because of its small diameter. The intake structure for the outlet works and the base of the principal spillway riser pipe were below the level of the reservoir at the time of the inspection and could not be observed. Plans showing the configuration of the principal spillway and the outlet works are non-existent. The emergency spillway channel is highly erodible and could be seriously damaged during high flows. It is not likely that this will cause damage to the dam unless left unmaintained between high flow events. No downstream warning system is in effect.

RECOMMENDATIONS

Because of the storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of these report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

Develop and immediately place in action a downstream warning plan, for use in the event of possible dam overtopping or structural failure. Inspect the principal spillway riser pipe, low-level outlet works, and discharge conduit and repair or replace as necessary. Care should be taken to inspect the area at the bottom of the riser since this area is subjected to falling water and could be experiencing erosion. Provide maintenance to the emergency spillway between periods of high discharge. Conduct more detailed hydraulic and hydrologic studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. Correct the seepage condition adjacent to the outlet conduit. Install piezometers in the dam. Investigate the cause of the downstream slope failure and modify the embankment as required to conform with inspection guidelines. Correct erosion of the upstream face with properly designed riprap protection. Conduct periodic inspections of the project at 5-year intervals by engineers experienced in dam design and construction.

RICHARD L.
FOSTER
2646 E

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID No.	MT-349
Owner/Operator	State of Montana, Department of Fish, Wildlife, and Parks
Date Constructed	1962
Purpose	Recreation and Minor Irrigation
Location	Sections 15 and 16, T21N, R58E Principal Meridian
County, State	Richland County, Montana
Watershed	Crane Creek, Tributary of Yellowstone River
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Crane, Montana

2. RESERVOIR

Surface Area at Spillway Crest	43 acres
Drainage Area	32.0 square miles
Storage at Assumed Principal Spillway Crest, Elevation 2001.8 ft. NGVD	505 acre-feet
Storage at Assumed Emergency Spillway Crest, Elevation 2005.0 ft. NGVD	645 acre-feet
Storage at Assumed Dam Crest, Elevation 2011.8 ft. NGVD	1,020 acre-feet
Surcharge Storage	515 acre-feet, including 375 acre-feet between emergency spillway crest and dam crest

3. PRINCIPAL SPILLWAY

Type	Uncontrolled, drop inlet, connected to discharge conduit
Bottom Width (Riser and Conduit)	24-inch-diameter CMP
Crest Elevation	2001.8 feet NGVD (assumed)
Capacity with Reservoir at Dam Crest	45 c.f.s.

4. EMERGENCY SPILLWAY

Type	Uncontrolled, unlined channel
Bottom Width (at Control Section)	100 feet
Crest Elevation	2005.0 feet NGVD (assumed)
Capacity with Reservoir at Dam Crest	5,600 c.f.s.

5. OUTLET WORKS

Conduit	24-inch-diameter CMP (also principal spillway conduit)
Conduit Length	170 feet (assumed)
Gate	24-inch-diameter gate valve
Capacity with Reservoir at Principal Spillway Crest	30 c.f.s.

6. DAM

Type	Earthfill
Length	1,000 feet (approximate)
Crest Width	20 feet
Crest Elevation	2011.8 feet NGVD (assumed)
Hydraulic Height (Crest to Toe)	30 feet
Upstream Slope	1 V on 4 H
Downstream Slope	1 V on 2 H

Chapter 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Gartside Dam, owned and operated by the State of Montana Department of Fish, Wildlife, and Parks.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1, of the U. S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

1. A limited investigation to assess the general safety condition of the dam.
2. Based upon an evaluation of the available data and a visual inspection.
3. Performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.
4. Not intended to include extensive explorations or analysis, nor to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a brief visual inspection of the project and review of available construction plans. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Rick Eckerlin, Corps of Engineers

Art Taylor, State of Montana, Department of Natural Resources and Conservation

Dave Conklin, State of Montana Department of Fish, Wildlife, and Parks

Tom Campbell, State of Montana Department of Fish, Wildlife, and Parks

CH2M HILL personnel who participated in the field inspection and/or contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader

Jerry Jacksha, Geotechnical Engineer

Loren Bottorff, Hydrologist/Hydraulics Engineer

Shari Gruver, Hydrologist/Hydraulics Engineer

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Gartside Dam is located on Crane Creek in Richland County, Montana, approximately 0.75 miles northwest of Crane and 10 miles southwest of Sidney, Montana (see Plate 1). The National Dam Inventory for Montana lists Gartside Dam as having a high (Category 1) downstream hazard potential. The Federal identification number is MT-349. The dam is 30 feet high, approximately 1,000 feet long, and impounds 1,020 acre-feet at dam crest, assumed elevation 2011.8 feet NGVD (see Plate 2). Construction was completed in 1962. Based on a brief field inspection and engineering judgment, we believe that several homes, the Lower Yellowstone Project Main Canal, a highway, and a railroad could be affected by a sudden breach of the dam. On the basis of this information and in accordance with the recommended guidelines, the project size is intermediate and the downstream hazard potential is high (Category 1).

The 43-acre reservoir is used primarily for recreation, with minor withdrawals for irrigation use. The dam is owned and operated by the State of Montana Department of Fish, Wildlife, and Parks.

The principal spillway is located near the center of the dam and consists of an uncontrolled 36-inch-diameter CMP drop inlet connected to a 24-inch-diameter CMP riser and discharge conduit. The emergency spillway consists of an uncontrolled, unlined channel excavated through the right abutment. The channel is approximately 100 feet wide at the crest.

The low-level outlet consists of a gated 24-inch-diameter CMP conduit that enters the principal spillway riser pipe and discharges through a common 24-inch-diameter CMP conduit.

About 1,000 feet downstream of the dam is the main canal of the Lower Yellowstone Project (see Plate 1). The flows from Gartside Dam cross the canal on a concrete overchute. A failure of the overchute could cause failure of the canal, which would cause some downstream flooding.

1.2.2 Regional Geology and Seismicity

Gartside Reservoir lies in an area that consists of gently rolling plain within the western portion of the Williston Basin. The sediments at and near the surface consist of the Paleocene Fort Union Formation. In this region the formation is composed of thick, interbedded, gray to buff sandstone, clay shale, lignite, and carbonaceous shale. The average regional dip is less than 1 degree to the east-southeast. Structural features are essentially subdued and have probably been inactive since the Cretareous.

The dam lies in an area of very low seismic activity. The closest historic seismicity was a magnitude 3.8 event that occurred in 1975, 53 miles north from the dam. The Inspection Guidelines Seismic Zoning Map shows the site in Zone 1, a zone where minor damage can be expected from earthquakes. Based on historic seismicity, little risk is expected.

1.2.3 Site Geology

Both abutments of Gartside Dam are founded in yellow to red, thinly laminated clay shale bedrock. A coal stratum, lying practically horizontal and 15 to 20 feet thick, is interbedded with the clay shale on the right abutment. This lignite coal seam lies between elevation 1985 feet and 2005 feet NGVD. The coal seam is not exposed on the left abutment. The dam spans the Crane Creek flood plain, approximately 1,000 feet wide, and is presumed to be founded on clay and silty sand alluvium.

The 600-foot-long spillway is excavated through the right (south) abutment and consists of an unlined channel cut in clay shale and lignite coal. The lignite coal seam forms the spillway floor and portions of the spillway side slopes. About 500 feet downstream from the spillway inlet, the coal seam thins to about 6 inches thick and overlies wet gray clay. The remaining 100 feet of spillway floor consists of clay, silt, and sand colluvium. Clay shale is exposed in the side slopes of the spillway channel and is heavily weathered to clay. Precipitation runoff apparently has incised many rills into the spillway channel side slopes.

1.2.4 Design and Construction History

Mr. Tom Campbell of the State of Montana, Department of Fish, Wildlife, and Parks, stated that the dam was started by a beaver, raised by a downstream rancher and completed in about 1962 by the Richland County Sportsmen's Club. Many individuals contributed to the most recent effort; however, only a few drawings, showing topography and dimensions of the embankment and spillways, are available. No information on foundation conditions or construction control is available.

Chapter 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Principal Spillway

The principal spillway and the low-level outlet works at Gartside Dam discharge through a common conduit that passes through the embankment. The principal spillway consists of a single, vertical, uncontrolled, drop-inlet riser pipe located in the reservoir near the center of the dam (see Photos 3, 4 and 5).

The drop-inlet principal spillway consists of a section of 36-inch-diameter CMP riser pipe with an 18-inch-wide slide gate (Photo 3). The slide gate operates as a weir, which can be lowered to permit flow when the reservoir level is below the spillway crest. When fully raised, the top of the gate is at the elevation of the spillway crest. The gate is operated from the riser pipe. The gate was operational at the time of the inspection. The crest of the riser pipe is at assumed elevation 2001.8 feet NGVD, which is 10.0 feet lower in elevation than the low point on the dam. A trashrack, formed of rebar, extends above the spillway riser (Photo 3). The 36-inch circular section of CMP riser reduces to a 24-inch-diameter 4.5 feet below the spillway crest. There are no design plans showing the configuration at the base of the principal spillway, which was under water at the time of the inspection and could not be observed.

There are no plans showing profile or details of the discharge conduit. The CMP conduit length from spillway riser to the downstream toe was estimated to be approximately 140 feet and was assumed to be 24-inch-diameter for the entire length. The discharge conduit ends at the toe of the dam in a concrete diversion box approximately 66" x 32" x 36" high (Photo 4). The normal discharge from the diversion box is to a large swampy area at the toe of the dam. The diversion box can be fitted with stoplogs to direct flow into an 18-inch-diameter CMP line which feeds an irrigation ditch. During the inspection, the stoplogs were put in place in order to partially pressurize the discharge conduit. An estimated 20 gpm of seepage occurred where the conduit emerged from the embankment when the stoplogs were in place. The discharge conduit could not be inspected because of its small diameter.

The principal spillway with the slide gate fully raised was assumed to function as a sharp-crested weir with a discharge coefficient of 3.3. A Manning's "n" of 0.024 was used to compute full-flow conditions in the riser and conduit.

The maximum principal spillway discharge, with the reservoir level at the top of dam, assumed elevation 2011.8 feet NGVD, is 45 c.f.s.

2.1.2 Emergency Spillway

The emergency spillway for Gartside Dam consists of an excavated channel in the right abutment (see Photo 6 and Plate 4). The channel bed is composed of highly erodible powdered coal, which is overgrown in places with grass and small trees. The channel is approximately trapezoidal in cross section with base width varying from 100 to 140 feet, with 2:1 slide slopes. The emergency spillway rating was developed by assuming critical depth occurs at the spillway crest and computing backwater effects in the approach channel between the reservoir and the control section, assuming a Manning's "n" = .027. The minimum elevation at the 100-foot-wide control section is at assumed elevation 2005.0 feet NGVD. The estimated emergency spillway discharge with the reservoir level at the top of dam, assumed elevation 2011.8 feet NGVD, is 5,600 c.f.s. The spillway rating curve is presented on Plate 5.

The spillway channel is about 600 feet long, with a slope of about 0.04. The channel discharges to a swampy area at the toe of the dam. The spillway could be highly eroded during a large flow event, but this is not likely to cause damage to the dam unless left unmaintained between large flow events.

2.1.3 Outlet

The outlet works consists of a 24-inch-diameter slide gate (which was operated during the inspection) and an undetermined length of 24-inch-diameter CMP line that discharges to the interior of the principal spillway riser pipe. Plans showing the configuration of the outlet works do not exist. The intake structure was below the reservoir level at the time of the inspection and could not be observed. The control for the outlet works slide gate is mounted on a concrete pad located on the upstream face of the dam. The valve stem is laid along the embankment slope. The discharge capacity of the outlet works with the reservoir level at the principal spillway crest, assumed elevation 2001.8 NGVD, is estimated to be 30 c.f.s.

2.1.4 Freeboard

Flood routings (see paragraph 2.2.4) indicate that the dam overtops during the PMF. Therefore, the dam has no freeboard with the recommended spillway design flood. The vertical distance between the low point on the dam and the reservoir level at the time of the October 30, 1979, inspection was 10.7 feet. The crest of the dam varies approximately 1 foot in elevation along its 1,000-foot length. The effective

fetch for wind-generated waves on the reservoir is about 0.3 mile. Wave runup on the embankment is estimated to be about 2.0 feet. Although the dam will overtop during the PMF event, the vertical distance between the crest of the dam and the normal reservoir level is adequate to prevent overtopping of the embankment by wind-generated waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the Gartside Dam basin area is continental, characterized by warm summers, cold winters, and a semiarid precipitation regime. There are two climatological stations, both located about 10 miles from the dam site. The station at Sidney, located to the northeast of the dam, at elevation 1920 feet NGVD, has over 30 years of records. The station at Savage, located to the southwest of the dam, at elevation 1985 feet NGVD, has over 70 years of records. Mean annual precipitation at Savage is 14 inches, with 54 percent occurring from May through July. Mean December precipitation is 0.25 of an inch and mean June precipitation is 3.45 inches. Mean annual precipitation on the Gartside Dam drainage basin may be near 14 inches. The mean annual temperature at Savage is 43.0 degrees Fahrenheit (°F) with monthly mean temperatures ranging from a low of 12.1°F in January to a high of 70.8 in July. Temperature extremes may range from -40°F to over 100°F. Winters have few extended cold spells; warm, windy, chinook weather occurs between cold spells. Temperatures on the Gartside Dam drainage basin may average about the same as Savage and Sidney.

The drainage area above Gartside Dam is 32 square miles in size. The basin is approximately 18 miles long and averages less than 2 miles in width. Basin elevations range from 2010 feet NGVD at the dam to 2720 feet NGVD at the western boundary of the basin. Land use in the basin is primarily range and grassland and is very sparsely populated. The basin is drained by Crane Creek, which enters the reservoir at the west end. Crane Creek has a relatively uniform gradient of about 40 feet per mile. There is no streamflow gage on Crane Creek or on any nearby streams.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 43 acres and a storage capacity of 505 acre-feet at principal spillway crest, assumed elevation 2001.8 feet NGVD, and a storage capacity of 645 acre-feet at emergency spillway crest assumed elevation 2005.0 feet NGVD. Approximately 515 acre-feet of storage is available in the reservoir between the principal spillway crest and the dam crest, including 375 acre-feet between the emergency spillway crest and the dam crest. The principal spillway discharge is 45 c.f.s. (4 acre-feet per hour) and

the emergency spillway discharge is 5,600 c.f.s. (460 acre-feet per hour) with the reservoir level at dam crest.

2.2.3 Estimated Probable Maximum Flood

The inspection guidelines recommend that the spillway design flood (SDF) for a project of this type be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A preliminary estimate of the PMF was made during this dam safety analysis, and this PMF was routed through the reservoir.

The procedure contained in Hydrometeorological Report No. 51 (Ref. 2) was used to compute the probable maximum precipitation (PMP). The PMP was assumed to occur on frozen ground; therefore, no infiltration losses were considered. This storm produces 17.8 inches in 6 hours and 23.1 inches in 24 hours. The 72-hour precipitation computed by this method is 25.7 inches. A base flow of 160 c.f.s. was used for the entire flood.

A triangular-unit hydrograph for a 1-hour rainfall duration was developed for the 32-square-mile drainage basin using procedures outlined in USBR "Design of Small Dams" (Ref. 3). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program HEC-1 (Ref. 4). This preliminary estimate of the PMP produced a flood (PMF) with a peak of 64,900 c.f.s. and a volume of 44,800 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 4). The routing of the PMF was started with the reservoir level at the crest of the emergency spillway. The outlet works was assumed to be fully open for the entire flood.

Routing studies indicate:

a. During the full PMF the dam would be overtopped when approximately 11 percent of the flood volume had entered the reservoir.

b. Routings were made of hypothetical floods less than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 10 percent of the PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The 30-foot-high, curved-axis, earthfill dam has a crest width of about 20 feet and is 1,000 feet long. Available information is limited to sketches of the embankment section, and principal and emergency spillways. No design or construction control information is available. The upstream slope is 1 vertical on 4 horizontal and the downstream slope is 1V on 2H. The embankment section, shown on Plate 3, is believed to be homogeneous and a foundation cutoff is shown on some of the drawings. Two concrete seepage collars are shown on the 24-inch-diameter, low-level outlet conduit, which is located as shown on Plate 3.

Riprap 12 inches and smaller in size is provided on the upstream slope; however, no bedding was placed beneath the riprap and appreciable erosion has occurred (see Photo 9).

Photos 7 and 8 show a recent slide scarp on the downstream slope that is centered near the curve in the dam alignment. The scarp varies in height from 1 to 2 feet and is about 200 feet long and midway between the dam crest and downstream toe. No other longitudinal or transverse cracks were found. As seen in Photos 1 and 2, scattered trees and brush are growing along the downstream toe and upstream slope.

Materials for the construction were obtained from spillway excavation near the right abutment, from the left abutment, and probably from the reservoir area. The spillway cut (see Photo 11) shows a gravelly silt that may be typical of embankment materials.

2.3.2 Foundation Conditions, Seepage, and Drainage

Foundation conditions are unknown. If explorations were performed, the information is no longer available. However, the project history, if correct, is of some concern. Apparently, the site was initially a beaver dam that was improved by a downstream farmer. Later, a local sportsmen's group, with at least some guidance from SCS personnel, completed the structure. It is unknown if the beaver dam was removed or if a cutoff trench was actually constructed. It is likely that the slide scarp is associated with weak organic foundation soils that were not removed during the construction.

The downstream toe area from abutment to abutment, and for about 1,000 feet downstream, is a swamp (see Photo 2). No seepage was observed along the toe except adjacent to the low-level outlet conduit, as seen in Photo 5. This seepage is apparently flowing along the outside perimeter of the 2-foot-diameter conduit as the upstream gate was closed and there was no flow inside the conduit. Seepage was clear;

however, this is always an undesirable condition. Seepage was also observed at the left abutment contact (Photo 10) and in the abutment area left of the outlet works, and approximately 12 feet in elevation above the conduit invert.

The embankment does not incorporate any type of internal drainage; however, the embankment section did not appear wet on the downstream slope. There are no piezometers in the dam.

2.3.3 Stability

There is no information on embankment strength parameters or internal water levels and no stability analysis is on file, as required for high-hazard structures.

While embankment stability is not critical, a section of the dam has recently developed a slide scarp (failure) on the downstream slope face that requires investigation as soon as possible. Until the investigation is complete and the dam section modified, as required by the recommended guidelines, the dam is structurally unsafe.

2.4 PROJECT OPERATION AND MAINTENANCE

Gartside Dam is owned by the State of Montana and is operated by the State of Montana Department of Fish, Wildlife, and Parks. There is no formal operation and maintenance program for the facility. Information about operations and maintenance was obtained through discussions with Mr. Tom Campbell of the Department of Fish, Wildlife, and Parks. The Department recently acquired ownership of the facility and has not yet established an operations and maintenance plan.

2.4.1 Dam

Maintenance of the dam is performed as required. It is visited daily by a game warden or by another employee of the Department of Fish, Wildlife, and Parks. The emergency spillway has a light growth of small trees and has experienced minor erosion.

2.4.2 Reservoir

The dam was built to impound water for recreational use. Irrigation water is provided to a single farm downstream. The drop inlet principal spillway keeps the reservoir level near a constant elevation at the spillway crest. Minor releases are made through the outlet works to provide irrigation water, as required, for the downstream farmer. The outlet control gate and discharge diversion box are operated by the farmer. The emergency spillway has reportedly carried

flow on several occasions, resulting in minor scour and erosion. According to Tom Campbell, there are future plans to draw down the reservoir each spring to protect the emergency spillway from potentially high runoff flows.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

Chapter 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Gartside Dam is intermediate in size and, based on our visual inspection and judgment, it has a high downstream hazard potential. Therefore, the guidelines' recommended spillway design flood (SDF) for this project is 100 percent of the PMF. Based on reconnaissance level investigations, the project is incapable of handling a flood having one-half the PMF ordinates without overtopping and causing the dam to fail which, in our judgment, would seriously jeopardize life and property downstream. Also, the 200-foot-long slide in the downstream embankment slope is of immediate concern. Under our criteria, Gartside Dam is considered unsafe until the recommended actions are complete.

3.1.2 Embankment Dam

A brief visual inspection of Gartside Dam found a 200-foot-long longitudinal failure crack and scarp on the downstream slope. The slope failure may be due to weak foundation materials.

The elevation of the dam crest, as determined by levels, indicated a maximum variation of 1 foot in the 1,000-foot-long crest.

Seepage of about 20 gpm adjacent to the outlet conduit was running clear. Other seepage areas were observed approximately 12 feet above the invert elevation of the outlet conduit at the contact between the left abutment and embankment, and in the abutment area immediately downstream.

There are no piezometers or other instrumentation at the dam. Several large willow trees are growing along the downstream toe area.

The riprap along the upstream slope has been displaced and embankment soils have been eroded.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of approximately 43 acres and a storage capacity of 505 acre-feet at assumed principal

spillway crest, elevation 2001.8 feet NGVD, and a storage capacity of 645 acre-feet at emergency spillway crest, assumed elevation 2005.0 NGVD. Approximately 515 acre-feet of storage is available in the reservoir between principal spillway crest and the dam crest, including 375 acre-feet between the emergency spillway crest and the dam crest. The discharge capacity of the principal spillway, with the reservoir at the dam crest, is 45 c.f.s. The principal spillway conduit could operate as a pressurized conduit through the embankment. There is no means of closing the spillway during operation. The discharge capacity of the emergency spillway, with the reservoir at the dam crest, is 5,600 c.f.s. The emergency spillway discharge channel is excavated through the right abutment in highly erodible material. High flows could cause serious erosion damage to the emergency spillway channel.

3.1.4 Outlet Works

The outlet works discharges to the 24-inch diameter principal spillway conduit. This pipe could not be inspected during the site visit because of its small diameter. The intake structure for the outlet works was below the level of the reservoir at the time of the inspection and could not be observed. Plans showing the configuration of the outlet works do not exist.

3.1.5 Operations and Maintenance

The State of Montana Department of Fish, Wildlife, and Parks has no operations and maintenance program or any inspection schedule for Gartside Dam. The reservoir water surface elevation is maintained by uncontrolled releases over the principal spillway and is usually at or near the elevation of the principal spillway crest. Minor releases are made through the outlet works to provide irrigation water, as required, to a single downstream user. The dam is visited daily by a member of the Department of Fish, Wildlife, and Parks staff. Maintenance is performed as required. According to Tom Campbell, there are future plans to draw down the reservoir each spring to protect the emergency spillway from potentially high runoff flows. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Storage between normal pool and the dam crest provides the present project with a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

The findings suggest that high priority be given the following recommendations:

1. Immediately develop, implement, and periodically test an emergency plan for alerting downstream residents in case of impending dam overtopping or structural failure.

2. Perform an inspection of the principal spillway riser pipe, low-level outlet works, and discharge conduit, and repair or replace as necessary.

3. Provide maintenance to the emergency spillway between periods of high discharge.

4. Remove all trees and brush from the dam embankment and downstream toe areas.

The above recommendations will not make the dam safe, but will reduce risk to life and property while the following recommended actions are being taken.

5. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

6. Investigate the dam foundation, abutments and embankment, conduct laboratory tests, install piezometers and establish water levels in the dam embankment, and conduct stability analysis. This study must be performed by qualified and experienced geotechnical engineers. Modify the embankment to provide stability in accordance with inspection guidelines.

7. Conduct a study to determine if the conduit through the embankment is pressurized during high flow conditions. If a significant pressure condition exists, develop a method of emergency closure of the principal spillway.

8. Correct seepage condition adjacent to the low-level conduit discharge.

9. Restore the upstream slope and provide riprap protection.

10. Periodic inspections of the facility should be conducted at 5-year intervals by engineers with experience in dam design and construction.

REFERENCES

1. U. S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U. S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. U. S. Department of Commerce, NOAA and U. S. Department of the Army, Corps of Engineers, Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian," Washington, D. C., June 1978.

3. U. S. Bureau of Reclamation, "Design of Small Dams," 2nd Edition, 1974.

4. U. S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING
STATE OF MONTANA
(406) 449-2872
HELENA, MONTANA 59601

September 19, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: CH2M/Hill Dam Safety Inspection Report of Gartside Dam (MT-349)

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it safisfies the criterial of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Gartside Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

"AN EQUAL OPPORTUNITY EMPLOYER"

DEPARTMENT OF FISH
WILDLIFE AND PARKS
STATE OF MONTANA
HELENA, MONTANA 59601

STATE OF MON

DEPARTMENT OF

FISH AND GAME

Helena, Montana
Aug. 28, 1980

Mr. Sidney Knutson
Seattle District
Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Sir:

We have completed our review of the Dam Safety Report for Gartside Reservoir MT-349. Our comments are:

1. The Department name is Fish, Wildlife and Parks.

2. On Page iv: How accurate is the determination of acre-feet? Were cross sections or soundings taken through the reservoir? If not the capacity could be well below 1000 acre feet, thus putting it into the small dam category.

3. The report classes the hazard as being high. Yet the guidelines state that the significant class is a few homes endangered - you say there are several. These would seem to be equivalent terms.

   The canal would be endangered - this is a relatively important utility. The highway is a state route - not a primary. And the railroad is a minor one - it is not on the main line. It would appear to us that the site more appropriately fits the significant hazard category.

4. Page V: This being the case the facility should be able to pass a flood between the 100 year event and half of the PMF.

5. The PMF has been determined to be 64,900 cubic feet per second. For comparison purposes the maximum flow ever recorded in the Yellowstone River at Billings is listed as 66,100 c.f.s.

6. You state the spillway will pass 5,650 c.f.s. The average flow of the Missouri River below Holter Dam is listed as 5,458 c.f.s. It would appear that the PMF is an extremely conservative figure. What would the rest of the country look like if an event of this magnitude were to ever occur?

7. Page 6: The statement made by Mr. Campbell is rumor and supposition. There is no hard evidence to back up this story. Is it advisable to include a statement of this nature in an engineering report?

8. Page 8: You have estimated the conduit length at 140 feet here. On page ix you estimate 170 feet.

9. Page 12: Were any reduction factors applied to the PMF?

10. Page 13: Why were the ground conditions assumed to be in a frozen state? Doesn't most precipitation occur in May and June?

11. Page 13: How good is the data on which the time of concentration is based?

We appreciate the opportunity to review your report and look forward to your revisions in accordance with our comments.

Sincerely,

Ron Holliday

Ron Holliday
Administrator
Parks Division

RH:SJ:an

cc: Mayer
Seaburg-Conklin

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

7 OCT 1980

Ron Holliday, Administrator
Parks Division
State of Montana
Department of Fish, Wildlife and Parks
Helena, Montana 59601

Dear Mr. Holliday:

Thank you for reviewing the Phase I dam safety inspection report draft on Gartside Dam, MT-349, and for presenting comments in your 28 August 1980 letter.

The criteria used for the dam inspection were those established by the "Recommended Guidelines for the Safety Inspection of Dams," which represents the comprehensive consensus of the engineering community. The guidelines recommend that the spillway design flood (SDF) be determined by taking into account the hydraulic height of the dam, reservoir size and the downstream hazard potential rating of the project. The inspecting Architectual-Engineering firm and the State of Montana Department of Natural Resources and Conservation (DNR & C), Office of Dam Safety, both concur that the downstream hazard potential rating for Gartside should be high and that the SDF be the full Probable Maximum Flood (PMF). These recommendations would be made in a Phase I study whether this dam was classified as being small or intermediate in size. Because the dam safety inspection limit the determination of the downstream hazard potential to a visual inspection and engineering judgment, we recommend additional studies to verify the hazard rating.

In regards to the PMF derivation, it was estimated based on accepted procedures and, although floods approaching the PMF may never have been historically experienced in the project area, represents what could happen. It is recognized that refinements in the preliminary PMF could either increase or decrease the final flood estimate. Please note that because this project can only handle a small portion of the total PMF volume (11 percent), it is possible that the dam could be overtopped, and subsequently failed, by a storm much smaller than the PMF.

The statement made by Mr. Campbell, which outlines the history of the dam, was included to show the order of events that occurred in the placement of the dam. The statement indicates that several stages of the project construction may have occurred without adequate engineering, planning or construction and is a significant consideration in understanding the project history.

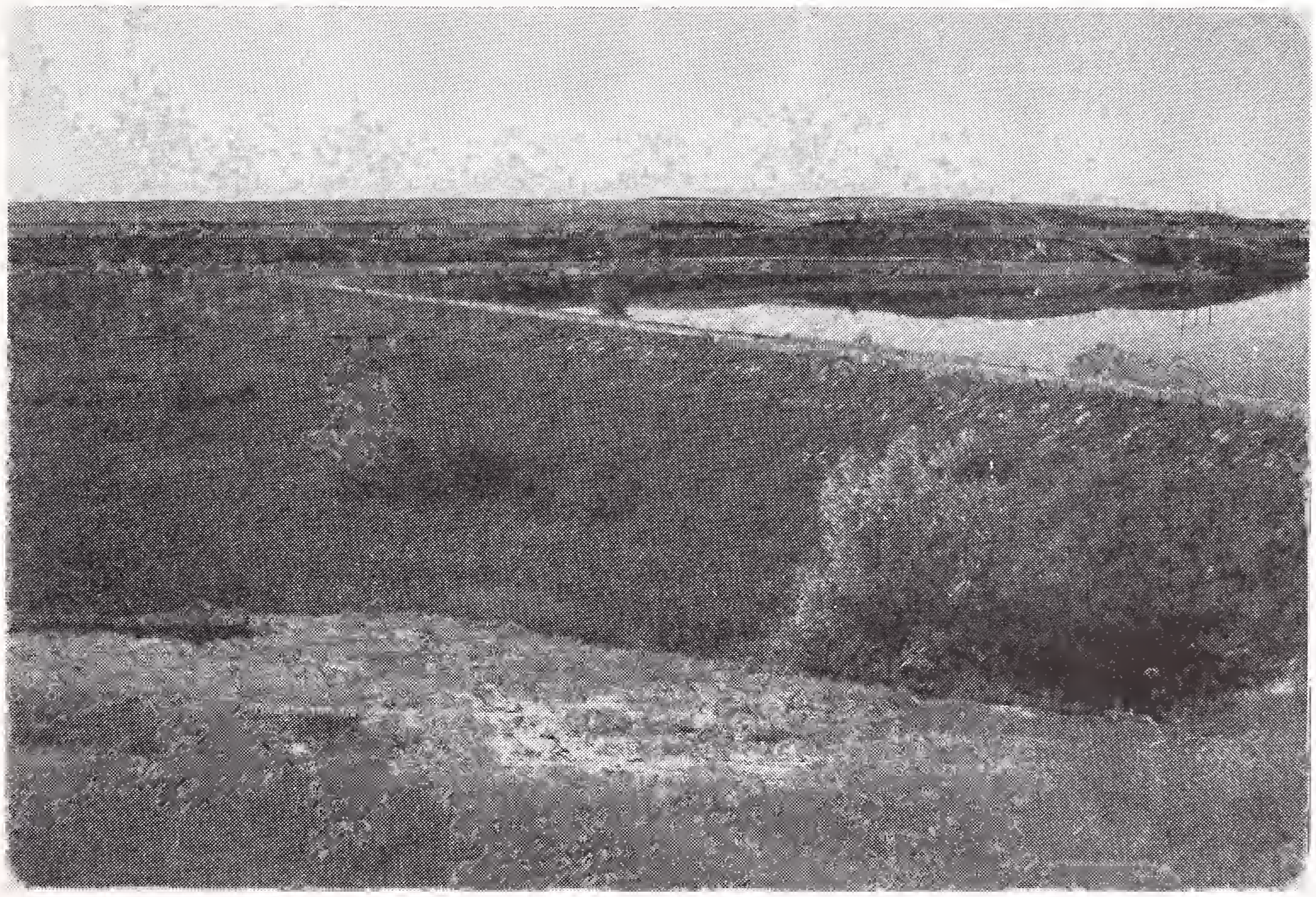
Your comment concerning the length of the principal spillway conduit is appreciated, and the dimension will be revised in the report.

Sincerely yours,

Sidney Knutson

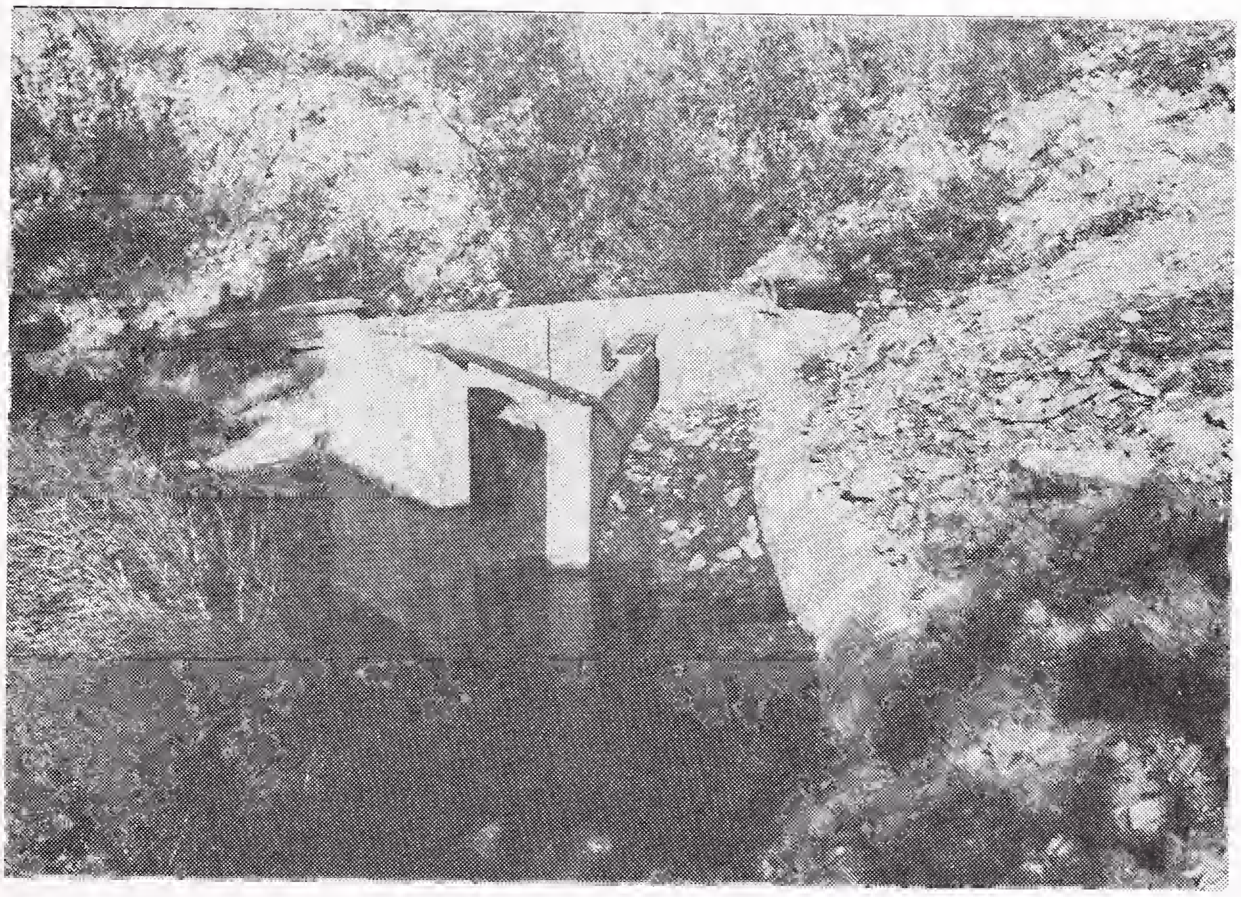
SIDNEY KNUTSON, P.E.
Asst Chief, Engineering Division

(PHOTO 1) VIEW OF DOWNSTREAM SLOPE FROM RIGHT ABUTMENT



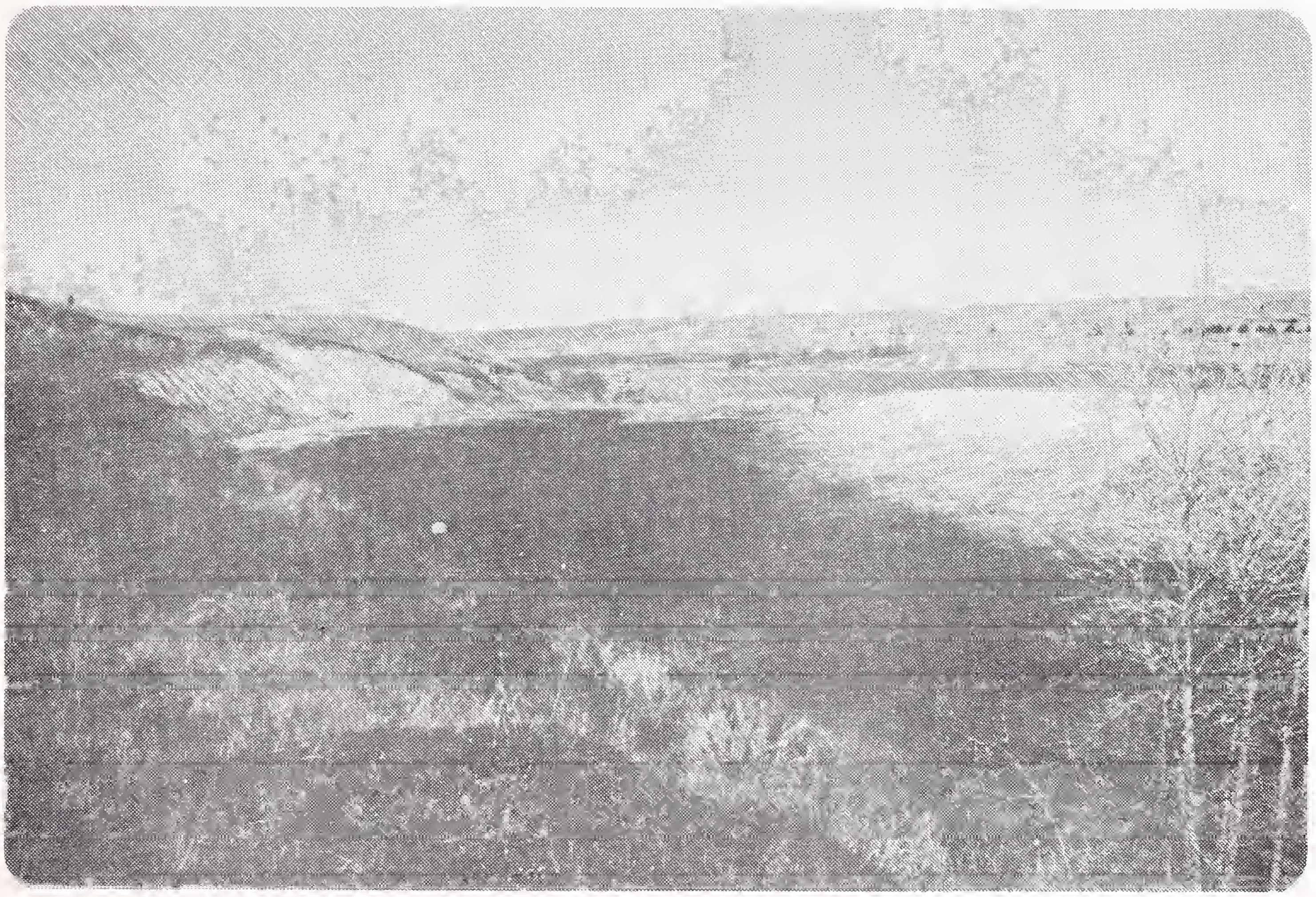
(PHOTO 2) VIEW OF DOWNSTREAM SLOPE FROM LEFT ABUTMENT

(PHOTO 3) PRINCIPAL SPILLWAY WITH TRASH RACK AND SLIDE GATE STEM

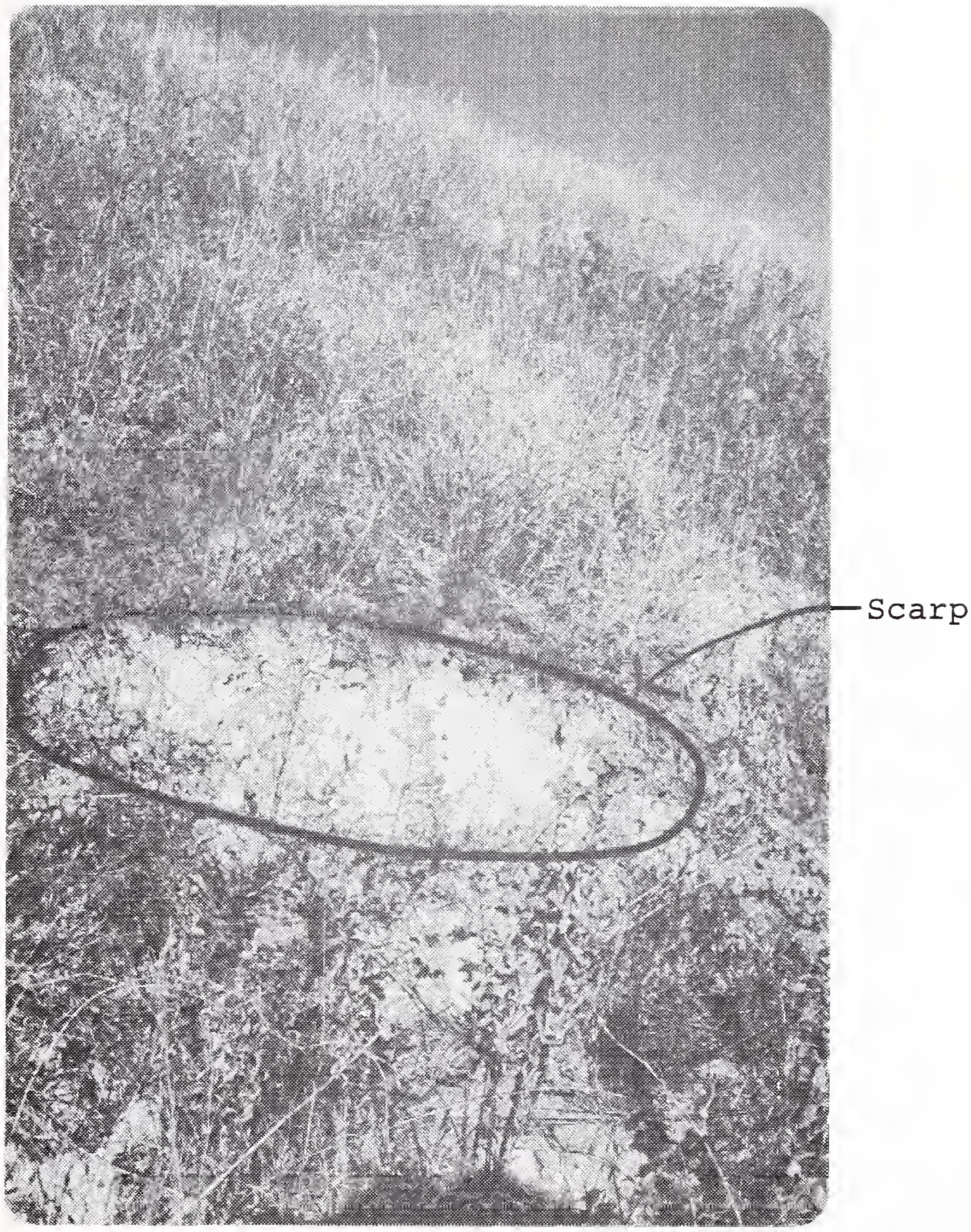


(PHOTO 4) OUTLET STRUCTURE, BOX, AND 18-INCH CMP IRRIGATION CONDUIT

(PHOTO 5) RIGHT SIDE OF OUTLET CONDUIT AND SEEPAGE



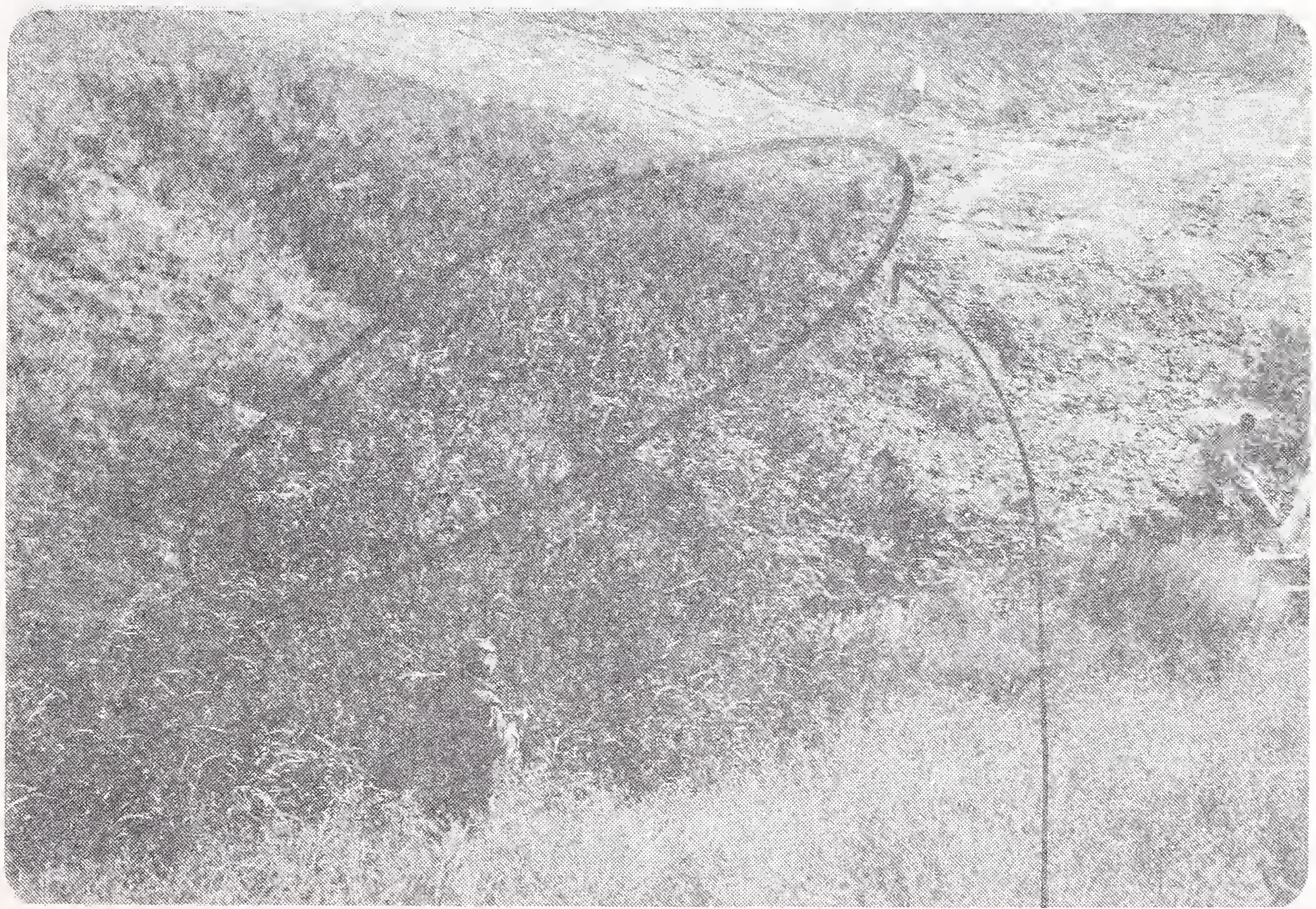
(PHOTO 6) SPILLWAY CHANNEL, COAL IN BOTTOM OF EXCAVATION



(PHOTO 7) SLIDE SCARP APPROXIMATELY
2.5 FEET HIGH

(PHOTO 8) VIEW ALONG SLIDE SCARP

(PHOTO 9) TYPICAL UPSTREAM EROSION



(PHOTO 10) LEFT ABUTMENT SEEPAGE

(PHOTO 11) MATERIALS IN SPILLWAY CUT THAT MAY HAVE BEEN USED IN THE EMBANKMENT CONSTRUCTION

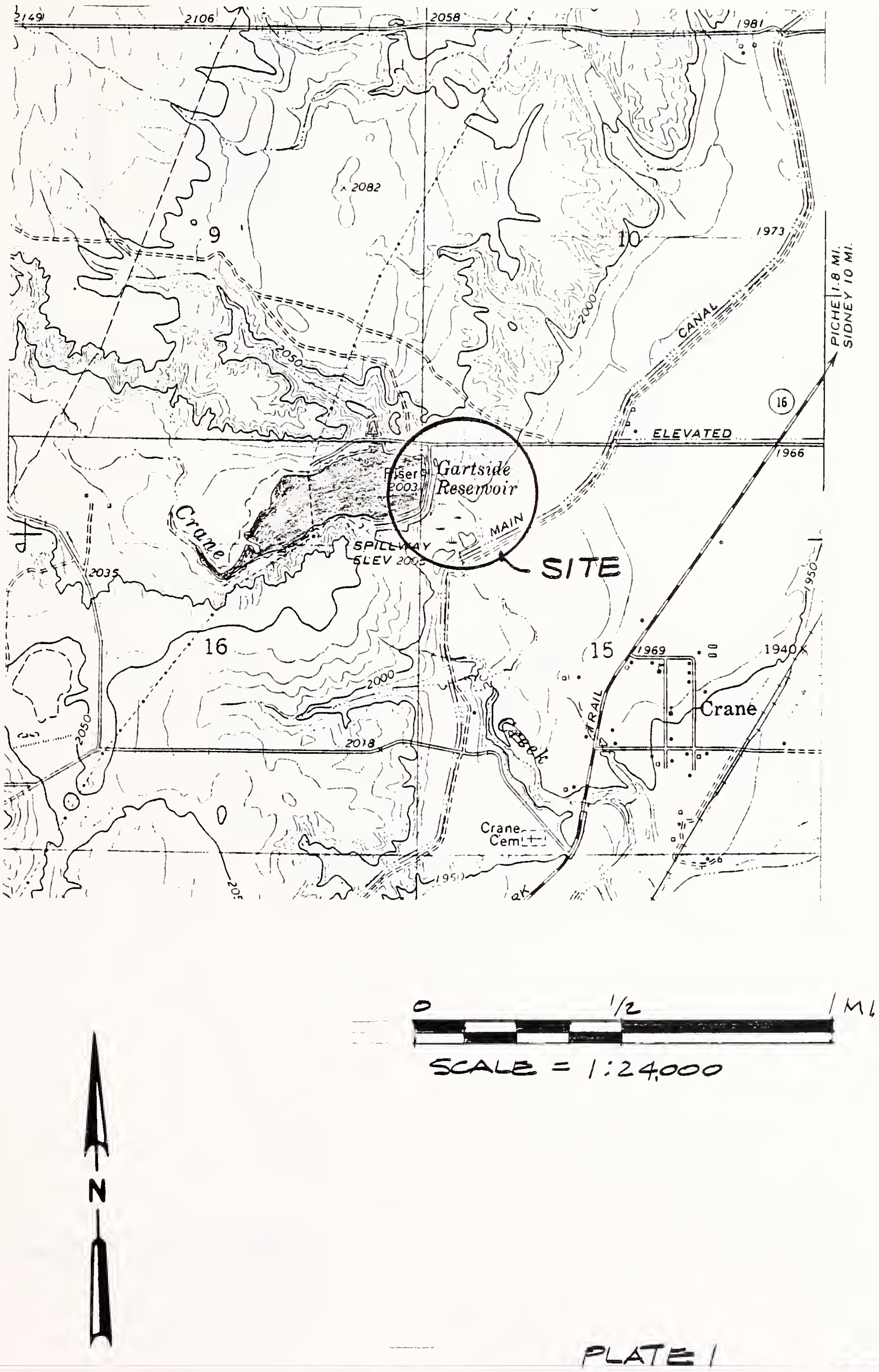
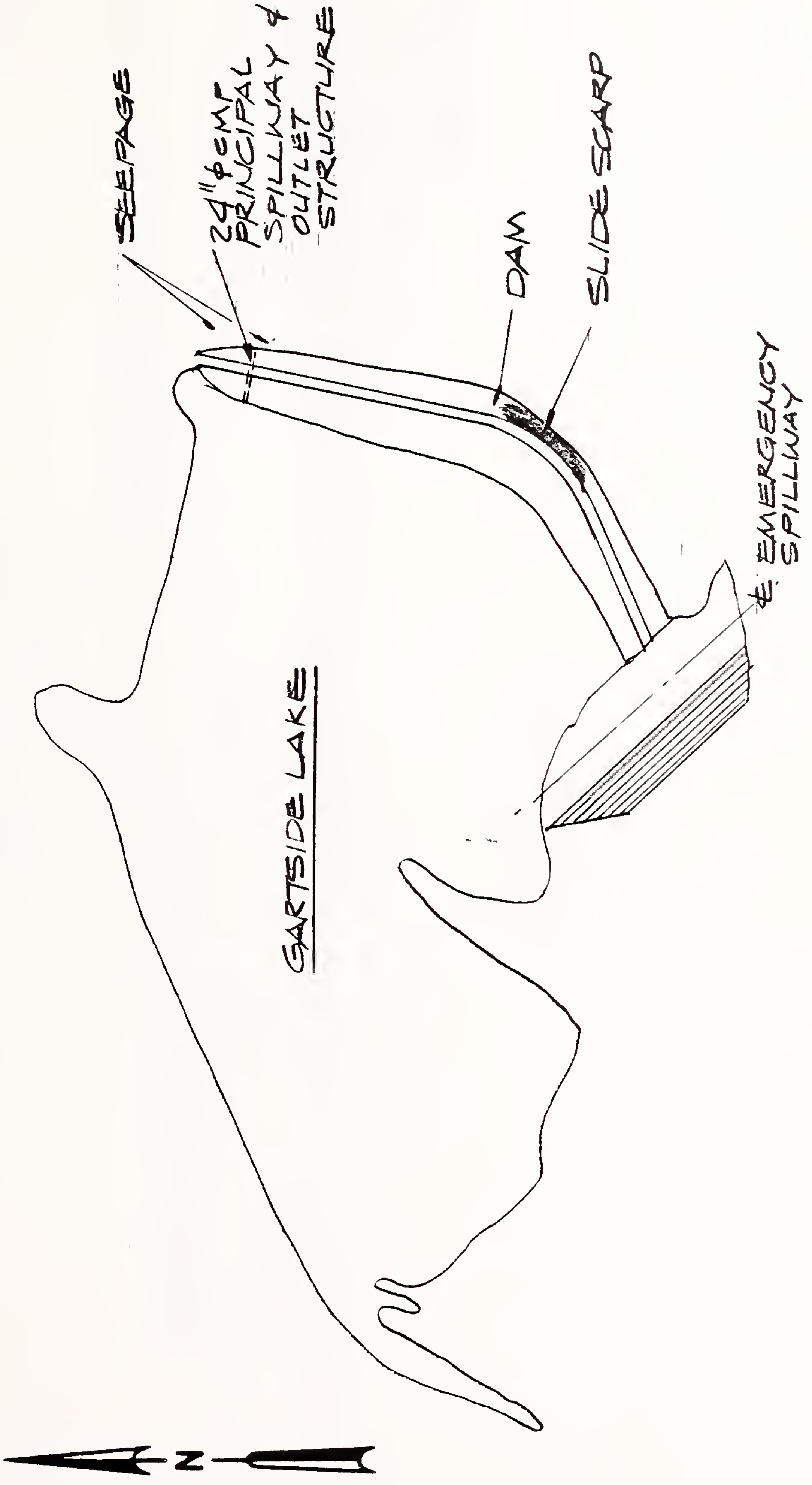


PLATE I

GARTSIDE DAM
VICINITY MAP

CH2M HILL

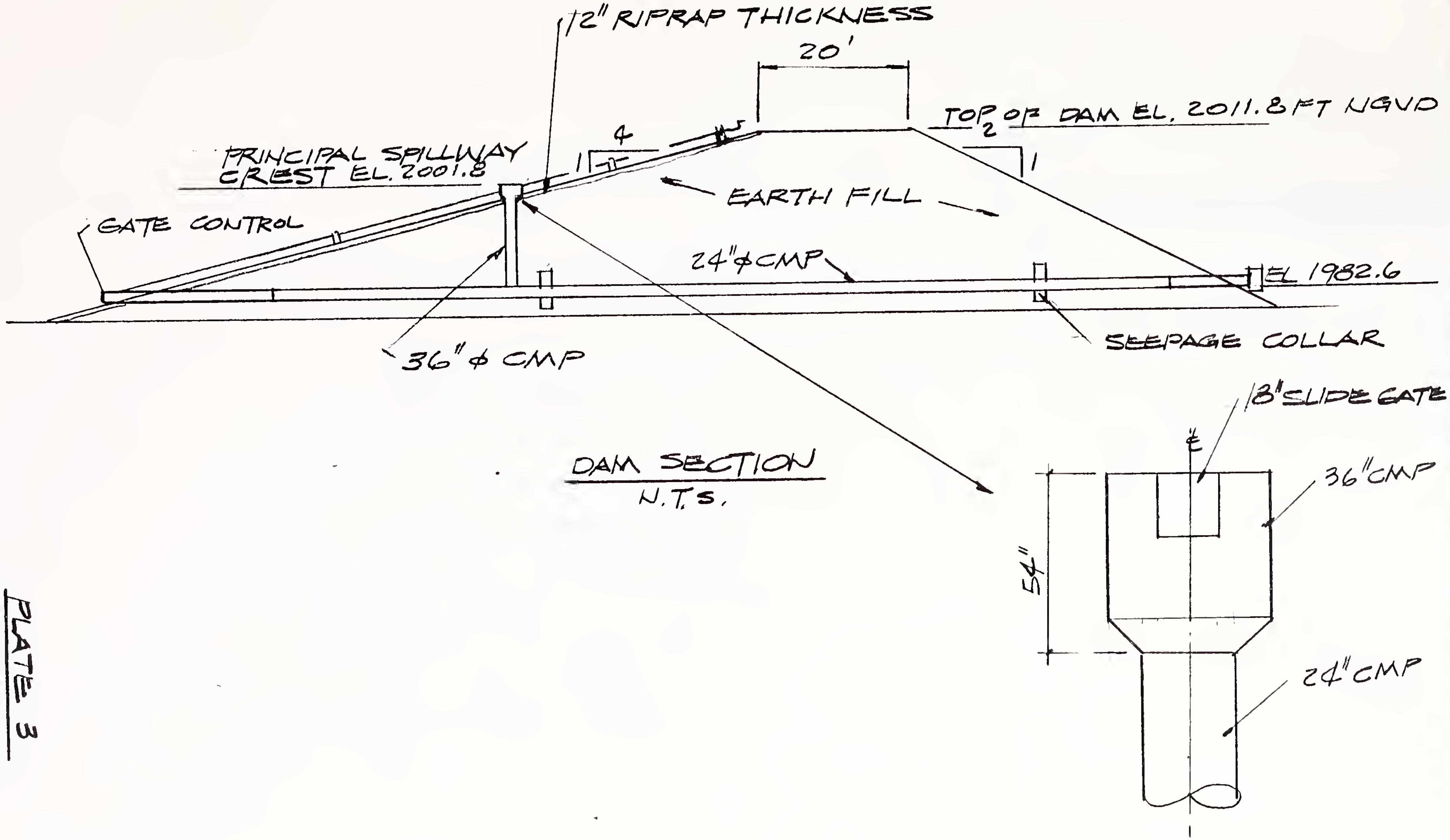


PLAN
N.T.S.

PLATE 2

GARTSIDE DAM
SITE PLAN

CH2M HILL

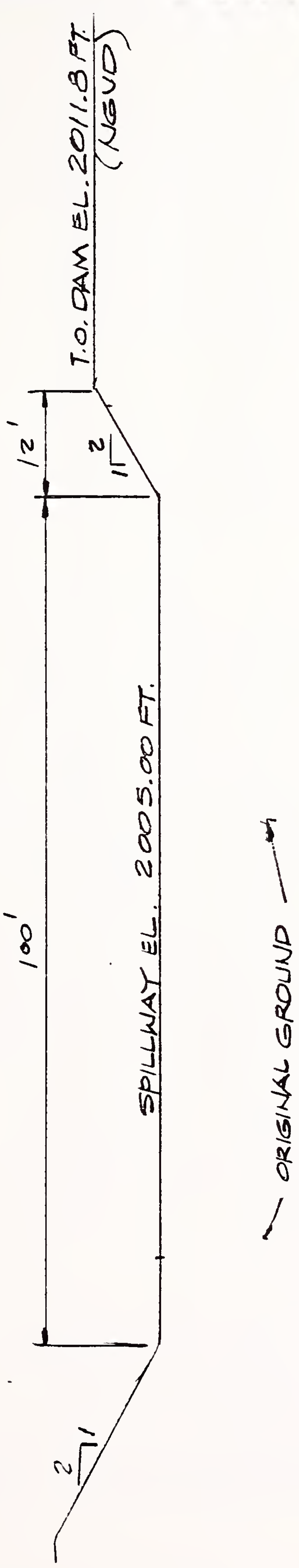


DAM SECTION
N.T.S.

DETAIL
N.T.S.

PLATE 3
GARTSIDE DAM
DAM SECTION & PRINCIPAL
SPILLWAY/LOWFLOW OUTLET

CH2M HILL



SECTION

N.T.S.

PLATE 4

GARTSIDE DAM
EMERGENCY
SPILLWAY SECTION

CH2M HILL

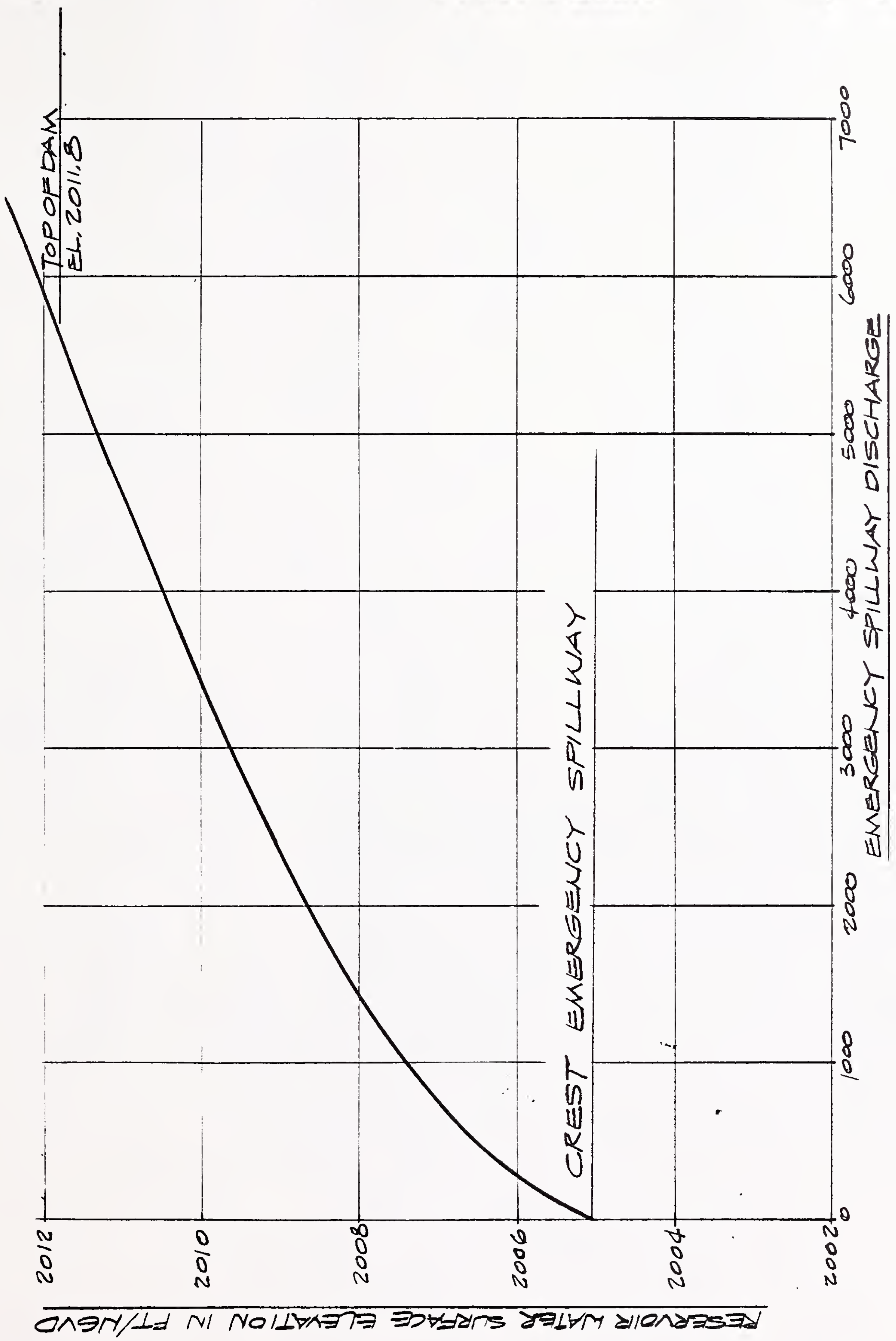


PLATE 5

GARTSIDE DAM
EMERGENCY
SPILLWAY RATING CURVE